Before the
Federal Communications Commission
Washington, D.C.

In the Matter of	)	ET Docket No. 03-104
Inquiry Regarding Carrier Current Systems	)	
Including Broadband over Power Line Systems	)	

Comments of the IEEE Power System Relaying Committee

Introduction:

The Power System Relaying Committee of the IEEE, Institute of Electronic and Electrical Engineers submits these comments on the Commission's Notice of Inquiry (NOI) in ET Docket No. 03-104. Power system protection is responsible for continuity of safe electrical service, by minimizing outages and equipment due to both natural and man-made electrical disturbances. The PSRC provides the power system protection element of electrical utilities, expertise in the form of guides, standards, recommended practices and papers.

The NOI is a request for technical information to make sure that Broadband over Power Line (BPL), if deployed, will harmonize with existing services. The Commission has recognized that the current Part 15 regulations may not be sufficient to permit the implementation of broadband technologies over power lines without disruption to existing licensed and non-licensed services. The Commission is seeking recommendations for changes to Part 15 to promote and encourage BPL technology. The inquiry is not a request for information on the technical viability or public need of BPL technology. Therefore, these comments are based on the assumption that BPL technology is viable for overhead and underground distribution system applications and that the test results from the pilot trials have warranted this inquiry.

Interference Concerns of Amateur Radio Operators:

There are many public comments posted regarding this NOI. It is apparent that much of the amateur radio community feels that interference is imminent with BPL. We have not had the opportunity to review results of measurements made during the many field trials. However the HomePlug standard group in conjunction with the Amateur Radio Relay League (ARRL) has demonstrated that it is feasible to develop BPL technology, with appropriate frequency and level restrictions such that the amateur radio community will not be exposed to any detectable interference from BPL. From the description of how the HomePlug and ARRL groups accomplished this, it appears that interference is being reduced by a "gentleman's agreement" rather than adherence to a technical requirement of Part 15. Part 15 should be changed to make this type of compliance a requirement. The HomePlug and ARRL groups' work focused on interference to amateur radio, however there are other radio services that need to be protected.

Benefit to Utilities:

For the utilities to deploy BPL on their systems, some basic principals need to be met.

1. The safety of the public and utility employees / contractors must not be jeopardized.
2. The reliability of energy delivery must not be jeopardized.
3. The quality of energy delivery must not be jeopardized. This includes conducted interference.
4. There must not be any negative impact to the environment. This includes airborne electromagnetic interference.
5. There must be a sufficient utility benefit.

Safety:

It would be a utility requirement that the transformer filters be able to be installed safely while the feeder and customers stay energized, so that customer service would not be adversely affected. Additionally it is a requirement that the failure of a filter cannot produce a safety hazard to the customer or utility. Electrical isolation between the transformer primary and secondary must not be compromised for any reason.

Power Quality Impact and New Sources of Interference:

The configuration of the power system utilizes low voltage distribution transformers for groups of customers depending on their physical proximity to one another. These transformers, being designed for 60 Hz coupling efficiency, do not pass frequencies in the BPL band very well. The NOI describes high-pass filters (bridges and couplers) that would go across the distribution transformers to allow the BPL signal to be conducted from the distribution feeder to the end user with less impedance. This has to be a two-way device at BPL frequencies. The NOI does not describe this device as being passive or active. It should be noted that if this device were passive, noise that currently is kept on the customer side of these transformers from sources such as motor noise, vacuum cleaners, SCR lamps etc, and In-House BPL would be conducted onto the feeder. This noise would then be conducted to a greater number of customers than currently exposed via the transformer secondary. Radiation of this energy would also increase. Additionally, noise present on the feeder from switching, transients, and lightning that are normally attenuated by the transformer would be passed on to the customers. If these devices are active and have the same spectral characteristics as the BPL devices themselves, new noise exposure would be limited.

Field Configurations:

The electric power distribution system has many configuration variations. It is impossible to imagine or specify a "standard" distribution feeder model that would represent all real systems. The system may contain conductors that approach "critical wavelengths", tuned stubs, have connected non-linear devices, and have configuration variations in height and separation. There may be parallel conductors on the poles or buried conductors beneath. The feeder conductors may be overhead, buried or a combination of the two. The customer load connections may be one, two or three phase. Additionally, outages due to maintenance, construction or storm damage may mean that the feeder will be connected to the system in a non-typical configuration to maintain the customer's supply of power.

There are several methods available to inject the BPL signal into the distribution feeders. However the power connections of the customers to the feeder may mandate the particular technique used. Generally, attempts are made to "balance" the load on the feeder. This means that the customers are connected such that an equal number of residential (or similar load) customers are connected to each of the three phases. However, each of the three phases do not need to be present throughout the feeder route. Only the phases being used need to be present. Therefore, it would probably be necessary to couple a BPL signal to all three phase -- either the same signal on all three phases or a separate signal on each phase. Separate signals on each phase may provide greater usable bandwidth due to a lower head-end to user ratio.

Changes to Part 15:

The ARRL has stated that they have been effective in eliminating interference to the Amateur Radio Service from HomePlug components by use of a spectral mask. The FCC could enhance Part 15 to provide a spectral mask that would define the permitted levels over the output bandwidth. The spectral mask needs to be considerate of HF Military, Amateur Radio, and Shortwave Radio allocations. It is likely that limitations on bandwidths may require more aggressive modulation schemes or slower data rates. However, avoiding interference is paramount.

It is clear that there must be a standard measurement description, which defines how the BPL equipment must perform. Due to the variations in the configuration of the power system, a defined measurement based on the equipment alone would not be sufficient to demonstrate compliance of either the conducted or radiated output signal. Part 15's radiation limit alone is insufficient. The FCC may want to consider an enhancement to Part 15 for equipment that is broadband in nature and/or will be connected to a variable impedance load.

The NOI states that the primary means in Part 15 for controlling interference is to limit radiated emissions. An alternative method for broadband or variable impedance devices would be to limit the radiation on a spectral basis as well as level. An example would be levels not to exceed –(x) dBm in any 4 KHz bandwidth from (y) Hz to (z) Hz conducted for a non-intentional radiator with a similar specification for radiated levels at a given distance for intentional radiators. The measurement antenna and distance should change depending on the frequency being measured.

It is essential that all BPL devices be tested using the same distribution system definition. Therefore a line impedance stabilization network (LISN) should be used. This will allow consistency and repeatability. This will also speed up the product acceptance process. It is essential that the LISN contain non-linear loads representing the real distribution system. This will assure that any intermodulation products produced by the BPL will comply with specifications of the spectral mask mentioned above. Any repeaters, filters should have the same spectral mask.

It is well known that making low level measurements with electrically small wavelength probes in close proximity to a large radiator will not provide an accurate capture of its emitted energy. An appropriate LISN, with measurement of the conducted signal only, will eliminate this problem. In order to facilitate the deployment of BPL, as well as have consistent field experience, the Access BPL and In-House BPL output characteristics, coupling characteristics and modulation schema, etc. should be standardized. Standards will allow rapid growth through interoperability. They will also insure that all equipment providers have the same interpretation of Part 15. If the standard design eliminates interference concerns, then no standard adherent equipment will cause interference. It is not essential that Access BPL and In-House BPL follow the same standard, however each should have a single standard if different.

Of concern is the modulation scheme on the BPL signal. If connected components on the distribution system produce non-linearity, the BPL will be partially rectified, or clipped. Components of the de-modulated signal will be impressed on unintentional radiators such as phone lines, cable lines and transmission lines. This is much like an AM radio signal producing audio frequency interference. There is concern that BPL on the distribution system may produce unwanted secondary signals and cause harmful interference. A deeper understanding of the signal type and its behavior is necessary. If the BPL signal is standardized, its interference would be able to be identified and possibly filtered.

Testing using a simulated home, office and power system is preferred to having full size model of an actual environment. There would be so many different environments that any model would be only “interesting” and not practical. It is more important to have a repeatable, definable, constructible test environment so that the results will be consistent, repeatable, and comparable.

<u>Part 15, Equipment Environment</u>:

The substation is a harsh location environmentally. Business or residential grade equipment will most likely be affected. The symptoms could be equipment failure or a change in a functionality or specification. In order for the head-end equipment to operate properly, it will most likely need to be built to substation environmental specifications. While survivability of BPL equipment is not specifically within the scope of the NOI, continued adherence to Part 15 when the equipment is installed on the power system is. IEEE P1613 “Standard Environmental Requirements for Communications Networking Devices in Electric Power Substations” as well as IEEE C37.90, C37.90.1, C37.90.2, C37.90.3 will be useful. One of the purposes of these standards would be to assure that a failure mode of the BPL equipment would not produce noise or allow the equipment violate part 15 when it is operating in its intended environment.

Part 15, Interference to PLC used for Protection from BPL:

Utilities currently use what is termed Power Line Carrier (PLC) as a communication channel to protect the transmission system. PLC is permitted between 9 kHz and 490 kHz spectrum. PLC systems are un-licensed but recognized as users of the spectrum under Part 15. PLC is the favored communication choice for the protection function due to its high reliability and low life cycle cost. Although more technically attractive protection communication mechanisms exist, offering more bandwidth, the unneeded expense associated with surplus bandwidth still favors use of PLC for protection. BPL, although utilizing the power system as a communication medium, cannot meet the technical requirements required to protect the transmission system. PLC can. Therefore, utilities would be adversely affected by any rule changes or added interference to PLC protection systems. BPL, as discussed in the NOI, should not interact with PLC or necessitate any rule changes as long as intermodulation products are minimal.

Discrete noise, i.e., noise at a given frequency, is of great concern to PLC operators. The signals described in the NOI have been discussed as wideband in nature. However, wideband signals can generate discrete signals out of band. We believe that, if the radiated signal level of any device, including BPL, within the PLC spectrum is maintained at the current levels under part 15, then the PLC can operate properly.

The NOI states that BPL could interfere with other services due to both radiated and conducted energy. It is the purpose of Part 15 to regulate emissions. Power Line Carrier systems are not subject to specific emissions limits. FCC regulations covering the PLC band and qualification for equipment are sufficient for both utility operations and non-interference to licensed users. Deployment of BPL will not necessitate adjustments to Part 15 for the PLC spectrum or equipment.

BPL as a replacement for PLC:

BPL is not expected to replace PLC as a utility protection tool. BPL, and Ethernet in general, is very robust in it’s ability to deliver messages. Descriptions of the BPL signal indicated that it would be able to deliver Ethernet data under conditions of power system noise on a distribution feeder. However, PLC is used on transmission lines having voltages between 69 and 765kV. It is not utilized on the lower-voltage distribution system. The noise levels on the transmission system are much higher. The only time that PLC is “used” is during power system faults which often collapse the faulted phase to near zero volts and produce as much as 40,000 amps of fault current. PLC uses 10 to 100 watt signals to assure successful operation during power system faults.

BPL utilizes message encapsulation protocol where Ethernet is transported. Delivery and bit error rate are of concern. Delivery time and its variation, known as latency, is not considered crucial for internet types of applications. PLC relies on delivery times of less than 4 ms. PLC also uses the line being protected as the transmission path. Multiple PLC signals are sent on different transmission lines during a system fault event. BPL would have to guarantee delivery times of less than 4 ms for all signals and be immune to noise in order to be considered for protection. Protection using Ethernet has been developed (UCA International, IEC 61850 "GOOSE" protocol); however, there are very stringent requirements for the network architecture to assure that the required delivery times and reliability are met.

PLC used on transmission lines have devices referred to as line traps (or wavetraps), which act as a blocking filter. This filter limits the PLC signal from being conducted to the next line, station bus etc. Additionally, it limits the PLC signal from being attenuated by a fault on a different system component or line. There are two types of traps available. One that blocks only the frequency being used and the other that is a wide band blocking filter. A trap at BPL frequencies would not be practical.

Some companies do not use line traps in situations where a line is connected directly to a transformer. They rely on the poor frequency response of the transformer at PLC frequencies as a sufficient blocking filter. It may be possible that a company will have conducted PLC signals on their distribution system. The do no harm to the PLC protection. However the PLC "leakage" may interfere with BPL signals.

<u>BPL for Utility Operations</u>:

With the introduction of BPL, a utility may have extensive communication connectivity to parts of its distribution system and customer location data. This data can be used to manage the power system as well as improve reliability. Effective use of network segmenting and firewalls at the head-ends can allow the utility to implement secure communications to distribution substations. However, data connections to customers over the distribution network itself could be capable of security breaches. Specific secure "Virtual Private Networking" systems would need to be developed for the downstream feeder network to be feasible for any type of control applications. Less security would be required if the network was implemented for data gathering, i.e. meter reading, outage detection, purposes only.

<u>Conclusion</u>:

Additional investigation on how BPL can be applied without causing interference to existing services must be explored. The ARRL has demonstrated that it is possible through spectral masking to eliminate interference to the amateur radio service. Changes must be made to Part 15 so that broadband signals, having low signal level at a given frequency, can be evaluated under consistent means regardless of the manufacturer or power system. Test must assure that intermodulation and failure modes of BPL systems do not cause interference.

Utilities may be able to use BPL to enhance power system operations; however security of BPL data will be a concern under certain situations. The PLC systems currently in use by utilities to protect their transmission systems cannot be replaced by BPL due to reliability and latency issues during system faults. The elements of Part 15 pertaining to PLC systems and equipment will not need to be changed to facilitate BPL.

Respectfully submitted,
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